do at Corpus Christi. These storms can be seen forming during summer afternoons and sometimes the thunder can be plainly heard at Corpus Christi, while the sky is clear from the Gulf horizon to within 5 or 6 miles of Robstown. It is reported that this same condition occurs at Kingsville. The reason is, of course, convection. The swiftly moving sea breeze prevents the formation of these thunderstorms (2) near the bays, but just as soom as this breeze ceases convectional thunderstorms occur, just as they do in any interior section. Occasionally these storms cause hail, and generally dangerous squalls, so aviators are careful in this area to avoid them. They can easily be avoided by airplanes flying as close to the Gulf as possible, and this is generally the course advised during summer by all planes flying in this area. Sometimes the planes coming from San Antonio or Brownsville are caught unawares, and have to encounter these storms, but with available reports of storms prevailing in the interior, with clear sky near the coast, it is easy for pilots to steer a course that will avoid these dangerous phenomena. The severity of the coastal storms has been discounted by some writers who have witnessed thunderstorms in the Mississippi Valley or other interior regions. However, it should be remembered that while these thunderstorms are rather quiet, with the thunder generally high, they are very dangerous to airplanes, because they have very strong upward currents, erratic squall conditions, and often hail. As an illustration of the dangerous type of these coast storms, two incidents are cited here:

On the occasion of an aerocade in 1929 the Weather Bureau at Corpus Christi and Brownsville furnished information at intervals of two hours during the progress of the flight from Houston to Brownsville. At 1 p. m. the planes left Corpus Christi for Brownsville, with clear weather at Corpus Christi, and overcast at Brownsville. There had been a few thunderstoms during the morning. Near Kingsville the planes encountered rain; farther south thunderstorms were seen. All but 2 of the 24 planes turned back and returned to Corpus Christi. One of the planes that continued reached Brownsville safely, the other one was blown off its course, and landed in a desolate spot in Mexico 100 miles south of Brownsville.

The other case of note was a 4-passenger plan returning to Kansas City from Aransas Pass, 24 miles east of Corpus Christi. The weather forecast issued that morning from the Corpus Christi office was for local thundershowers. The pilot received this forecast by telephone from the local office, but nevertheless took off for his homeward flight. Within 10 minutes after the start he encountered a thunderstorm, attempted to fly through it, and crashed, killing all the occupants of the plane. This thunderstorm was one without much thunder, but from evidence obtained after the crash the plane was carried upward several thousand feet and dropped on the other side.

CONCLUSIONS

From the above stated facts it is seen that flying weather in the Corpus Christi area is practically uninterrupted during the five months, May to September, inclusive, in so far as the greatest hazard to flying is concerned—fog. During the other months of the year the elements to be watched are the strong and erratic winds on this coast, and thunderstorms.

Wet "northers" are also a great handicap to planes traveling northward. When they prevail the ceiling is low, sometimes below 700 feet and occasionally 500 feet. Careful pilots in this area generally ground their planes when one of these annoying "northers" is expected. On the average about three to five such disturbances will occur in each month, November to March, inclusive.

(1) Heckathorn, Charles E. MONTHLY WEATHER REVIEW, June, 1919, pp. 413–415 Land and Sea Breezes in the Vicinity of Corpus Christi.

(2) Tannehill, Ivan H. MONTHLY WEATHER REVIEW, Sept., 1921, pp. 498–499, Wind Velocity and Rain Frequency on the South Texas Coast.

PILOT-BALLOON OBSERVATIONS AT HAVRE, MONT.

By FRANK A. MATH

[Weather Bureau Office, Havre, Mont.]

Although numerous compilations of balloon and kite data have been published in the MONTHLY WEATHER REVIEW, it was thought that some of the more or less interesting results obtained with pilot balloons at Havre, Mont., during a period of three years and five months would add another chapter for study.

Whenever permissible, two balloon ascensions are made daily. The hours of observation were 6 a. m. and 2 p. m. from the beginning, August 6, 1927, to March 31, 1930, after which the hours were changed to 4.30 a. m. and 4.30 p. m. to work simultaneously with other stations. While a total of 2,487 observations were possible, at two a day, during the period from August 6, 1927, to December 31, 1930, there were 2,392, or 96 per cent, actually made. The visibility recorded with each according to the scale, 0 to 9, as given on page 29, Instructions for Making Pilot Balloon Observations, was as follows:

Observations	Visibility	Percentage
1,149	9	48
658	8	27
337	7	14
119	6	5
61	5	3
57	4	2
11	3	1

This indicates a high per cent of the number of possible ascensions and, as a rule, good visibility, over the plains of central Montana. A further indication of good flying weather is the small number, 95 "no ascensions" in three years and five months, or less than 4 per cent of total possible. Snow was the cause of preventing 48 of these "no ascensions"; rain, 26; low clouds, 10; fog, 8; high wind, 2; smoke, 1. In this connection it may be said that occasionally during low temperature in winter, a light dry snow falls with visibility 5 or 6. At such times balloons can be observed to altitude 1,000 to 2,000 meters.

There were 773 balloons reached an altitude of 4,000 meters or higher, 42 reached 10 kilometers (6.2 miles) or higher; and 13 reached 11 kilometers. The longest time that any one balloon was observed was one hour and 25 minutes, reaching an altitude of 15,390 meters (9.4 miles) on March 15, 1929, the highest of record for this station. The highest velocity computed from any balloon observation was 45.3 meters per second (101 miles per hour) on December 24, 1929. One of the balloons was observed to a distance of 44,600 meters (27.7 miles) away from Havre. That was the farthest of record by observation.

The bottoms of the paper lanterns attached to the balloons during darkness are stamped with the name of

the station and date. Six of the lanterns were picked up by farmers in remote places and mailed back to this office. The one returned from the most distant point was found on a farm near Ray, N. Dak., 32 miles northeast of Williston, or about 300 miles east of Havre. Others returned were found as follows: 15 miles southeast of Malta, Mont., about 100 miles east-southeast of Havre; one on King Island, Missouri River, about 82 miles southeast; one crossed the International boundary about 4 miles into Saskatchewan, 65 miles east-northeast of Havre.

FREE-AIR WINDS

A table showing surface-wind frequency and frequency resultants was compiled from data taken from page 13, Form 1001, recorded by register for each hour of the day. The registration was made by anemometer and wind vane 44 feet above the ground. The 4-year period, 1927–1930, was used in this table in order that it may be used in comparison with those of higher altitudes which follow. In this Table No. 1, surface winds favor a westerly movement with southwest prevailing, except that during the late spring month of May and the summer months of July and August the prevailing surface winds are east. June has a close race slightly in favor of southwest. The velocities, as a rule, are light to moderate, average about 6 miles per hour. The highest velocities are from a westerly direction. They occur mostly in winter, although the highest surface wind of record occurred during a summer squall in June.

Another table of surface wind direction frequency for Havre was prepared by E. R. Miller from data for the 13-year period, 1891–1902, MONTHLY WEATHER REVIEW, July, 1927, page 310. The two tables are much in agreement for all directions except northeast and east, which appear to be in reverse order. This is probably due to the difference in location of wind vane. During the 13-year period two different locations are involved and both are different from the location of the vane used in the later tabulation. The resultants of the later table, computed by the same formula, show a greater south component than the previous compilation.

Three other tables were prepared showing the percentage of times winds were observed from eight principal points of the compass and the velocities of the winds from the respective directions as computed from pilot balloon ascensions observed by the 1-theodolite method subject to any errors by this method as explained by Reihle, page 628, MONTHLY WEATHER REVIEW November, 1920. The data were compiled for altitudes, 801 meters, 1,530 meters, and 3,060 meters above the surface during the three years and five months ended December 31, 1930. The surface of Havre is 762 meters above sea level; the longitude, 109° 40′ west; the latitude, 48° 34′ north.

At the 801-meter level (2,628 feet), Table No. 2, the westerly winds are more decided than at the surface. The prevailing east direction of certain summer months has fallen to a smaller percentage being overcome by westerly winds. However, the velocities of all directions show a considerable increase, about double the surface easterly winds and about four times the westerly. Reihle, on page 629, MONTHLY WEATHER REVIEW. November, 1920, states, "A rapid increase in velocity from the ground to approximately 500 meters occurs at all seasons; above this there is little or no increase to 1,500 meters and there may be a decrease." This is true also for Havre, see Table No. 5.

The data in Table No. 3 at 1,530 meters, (5,020 feet) show the prevailing westerlies gaining more in per cent of times especially in the winter months. The percentage of easterly winds at this level in the winter season, November-March, is small, although during the summer, April-September, the easterly winds maintain a good percentage. Gregg has pointed out, page 234, MONTHLY WEATHER REVIEW, May, 1922, "The more striking features are: (1) The greater percentage of easterly winds at all levels in summer than in winter * * *." The average velocity of all directions remains close to, or slightly less than, at 801 meters.

Table No. 4, data at 3,060 meters (10,039 feet), shows a still greater increase in the percentage of times of the prevailing westerlies and a corresponding decrease in the easterly directions. From November 1, to about May 1, the percentage of easterly winds is very small, practically no east or southeast during January to April inclusive, although during May and June and September and October, a small percentage of easterly winds at this elevation is recorded. The velocities show an increase in most cases above the other levels. The highest velocities are westerly; the average from southwest through west and north being 11.4 meters per second, while from northeast through east and south is 4.8 miles per second.

The mean-frequency resultants of free-air winds at Havre for the whole period of balloon records are:

Surface	S 75° W
801 meters	N 85° W
1,530 meters	N 84° W
3,060 meters	N 81° W

Table No. 5 is a summary of the above data arranged to show the variation of the velocity and frequency percentages of the eight wind directions for the four seasons of the year from the surface up to 3,060 meters. The results shown by these tabulations, as a whole, agree to a great extent with those outlined by Gregg, MONTHLY WEATHER REVIEW, May, 1922, and by Reihle, MONTHLY WEATHER REVIEW, November, 1920.

TABLE 1.—*Surface wind frequency, and frequency resultants, Havre, Mont., for the four years, 1927–1930*

	N.	NE.	E.	SE.	S.	SW.	W.	NW.	Calm	Frequency resultants
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	°
January	3	8	17	1	1	35	18	16	1	S. 79 W.
February	5	8	17	0	1	37	16	15	1	S. 78 W.
March	6	8	21	2	2	31	14	15	1	S. 80 W.
April	6	9	22	4	4	27	14	13	1	S. 69 W.
May	6	12	25	5	5	21	12	13	1	N. 34 W.
June	4	8	22	5	6	25	16	13	1	S. 61 W.
July	5	12	24	6	6	16	16	14	1	N. 18 W.
August	5	12	24	4	5	22	15	11	2	S. 64 W.
September	4	11	20	3	3	25	18	13	3	S. 88 W.
October	5	8	20	1	3	29	18	15	1	S. 84 W.
November	3	9	20	1	1	34	17	14	1	S. 73 W.
December	3	9	20	1	1	34	17	14	1	S. 73 W.

AVERAGE VELOCITIES, METERS PER SECOND, OF THE RESPECTIVE DIRECTIONS ABOVE CONVERTED FROM MILES PER HOUR

	N.	NE.	E.	SE.	S.	SW.	W.	NW.
January	2.1	1.9	2.0	0.8	0.9	5.2	2.5	2.3
February	2.5	1.7	2.2	0.0	1.3	5.2	2.5	2.8
March	2.8	2.0	2.2	1.9	1.4	4.8	3.0	3.4
April	4.6	2.7	3.2	2.1	1.7	4.5	3.3	3.4
May	3.1	2.4	3.1	2.3	1.8	3.8	3.2	3.4
June	2.5	1.8	2.3	1.9	1.7	3.9	3.3	3.6
July	2.4	1.8	2.2	2.0	1.6	2.9	2.3	2.9
August	2.4	1.8	2.1	1.4	1.3	2.8	2.0	2.5
September	2.4	1.8	2.0	1.3	1.8	3.4	2.5	3.2
October	2.8	1.8	2.1	1.2	1.3	4.4	2.9	2.9
November	1.7	1.9	2.4	2.0	1.1	5.3	2.4	2.9
December	2.0	1.7	2.3	0.7	1.1	5.7	2.7	2.6

TABLE 2.—*Percentage of time wind was observed from the following directions at 801 meters above the surface; period August 6, 1927–December 31, 1930*

	Number of observations	N.	NE.	E.	SE.	S.	SW.	W.	NW.	Calm
		P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct
January	165	5	3	1	1	3	10	38	39	0
February	150	7	1	1	1	1	22	31	36	0
March	166	8	5	4	2	4	18	35	24	0
April	164	10	4	6	9	4	19	34	14	0
May	174	7	8	9	13	9	17	24	13	0
June	163	4	7	9	14	4	15	28	19	0
July	178	10	7	9	8	9	17	24	16	0
August	226	5	5	10	11	9	17	24	19	0
September	220	9	4	7	7	7	14	29	23	0
October	226	7	2	2	10	4	21	37	17	0
November	209	4	2	2	5	4	14	39	30	0
December	215	2	1	1	2	4	14	46	30	0

AVERAGE VEOLOCITIES, MILES PER SECOND, OF THE RESPECTIVE DIRECTIONS ABOVE

	N.	NE.	E.	SE.	S.	SW.	W.	NW.
January	7.9	3.3	1.9	1.8	5.4	5.9	13.8	12.3
February	8.6	4.2	2.7	3.5	4.7	12.2	13.7	11.2
Mrach	7.0	3.0	4.2	10.0	4.7	11.1	12.7	9.8
April	5.7	4.0	7.3	10.9	5.3	7.4	11.1	7.3
May	6.0	5.1	8.5	9.8	5.9	7.0	10.2	7.1
June	5.4	3.9	8.6	4.6	4.9	5.5	10.5	10.0
July	4.7	5.8	7.0	5.9	4.0	5.7	7.4	7.5
August	4.9	3.1	5.9	5.9	5.5	5.9	7.9	6.4
September	6.1	4.7	3.4	4.5	5.0	6.6	9.0	8.3
October	5.0	6.7	5.0	4.5	8.1	9.4	12.5	10.1
November	9.4	6.0	5.9	4.4	4.4	11.7	13.5	10.9
December	11.0	3.6	6.5	4.9	5.1	10.1	15.4	10.7

TABLE 3.—*Percentage of time wind was observed from the following directions at 1,530 meters above surface; period August 6, 1927–December 31, 1930*

	Number of observations	N.	NE.	E.	SE.	S.	SW.	W.	NW.	Calm
		P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
January	133	5	1	0	2	1	10	33	48	0
February	125	6	0	0	0	1	11	37	45	0
March	140	9	1	2	0	1	14	44	29	0
April	144	3	2	3	6	6	15	42	23	0
May	160	9	8	3	6	9	19	35	11	0
June	153	6	2	7	6	10	16	35	18	0
July	169	5	5	5	5	10	24	31	15	0
August	216	5	2	2	10	10	21	30	20	0
September	196	8	2	2	5	11	18	30	24	0
October	201	5	4	3	3	4	12	48	21	0
November	174	5	0	1	1	5	9	45	34	0
December	175	3	1	1	1	4	7	39	44	0

TABLE 3.—*Percentage of time wind was observed from the following directions at 1,530 meters above surface; period August 6, 1927–December 31, 1930*—Continued

AVERAGE VELOCITIES, METERS PER SECOND, OF THE RESPECTIVE DIRECTIONS ABOVE

	N.	NE.	E.	SE.	S.	SW.	W.	NW.
January	9.0	2.3	0	3.8	3.0	7.1	13.9	18.0
February	8.9	0	0	0	8.2	11.1	13.5	12.2
March	6.4	7.2	6.9	0	7.4	9.9	13.2	10.8
April	8.1	4.2	5.1	9.7	5.0	8.0	10.0	13.0
May	6.7	4.1	5.6	5.3	6.8	5.5	9.8	6.9
June	4.3	3.0	6.9	4.9	5.5	6.4	10.1	9.9
July	5.6	4.7	2.9	5.6	3.6	5.8	8.5	6.2
August	3.4	6.4	2.2	4.8	5.0	6.0	7.4	7.0
September	6.8	3.8	4.7	4.8	5.6	6.7	9.6	9.9
October	5.8	3.5	3.2	4.5	3.1	8.6	11.5	11.8
November	8.6	0	10.1	3.8	5.9	9.4	13.2	13.5
December	9.2	3.2	2.3	3.4	6.4	11.1	13.6	12.7

TABLE 4.—*Percentage of time wind was observed from the following directions at 3,060 meters above surface; period August 6, 1927–December 31, 1930*

	Number of observations	N.	NE.	E.	SE.	S.	SW.	W.	NW.	Calm
		P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
January	56	6	2	0	0	0	2	34	56	0
February	58	12	2	0	0	2	9	36	39	0
March	73	15	1	0	0	0	4	52	28	0
April	84	4	2	0	0	2	19	49	24	0
May	121	9	3	3	3	5	19	41	17	0
June	109	5	3	2	2	6	18	38	26	0
July	146	3	0	1	0	1	27	51	17	0
August	170	2	1	1	2	5	22	47	20	0
September	119	4	3	3	1	6	15	35	33	0
October	120	2	3	2	2	3	12	48	28	0
November	89	6	1	0	4	1	7	39	42	0
December	69	12	0	1	3	3	7	35	39	0

AVERAGE VELOCITIES, METERS PER SECOND, OF THE RESPECTIVE DIRECTIONS ABOVE

	N.	NE.	E.	SE.	S.	SW.	W.	NW.
January	13.8	8.4	0	0	0	3.2	13.1	16.2
February	15.1	16.2	0	0	8.7	10.0	14.6	13.1
March	10.5	7.3	0	0	0	11.4	14.4	13.9
April	9.1	13.0	0	0	4.7	9.2	12.3	12.5
May	5.3	5.7	3.4	5.6	10.4	10.5	10.3	11.3
June	6.5	2.4	5.4	7.1	9.9	9.3	12.3	10.7
July	7.1	0	5.0	0	6.9	13.0	11.9	7.9
August	7.7	1.1	7.7	7.2	6.6	10.8	11.5	9.2
September	8.9	3.9	6.5	6.2	7.8	12.7	11.3	13.1
October	7.6	8.9	6.5	5.9	13.4	11.4	13.3	14.2
November	14.6	3.2	0	1.2	4.9	12.4	13.7	15.5
December	13.3	0	3.2	5.3	9.2	8.7	13.1	16.0

TABLE 5.—*Seasonal winds at different altitudes*

SUMMER

Altitude	North		Northeast		East		Southeast		South		Southwest		West		Northwest		Calm
	Velocity (m. p. s.)	Per cent	Velocity (m. p. s.)	Per cent	Velocity (m. p. s.)	Per cent	Velocity (m. p. s.)	Per cent	Velocity (m. p. s.)	Per cent	Velocity (m. p. s.)	Per cent	Velocity (m. p. s.)	Per cent	Velocity (m. p. s.)	Per cent	Per cent
Surface	2.4	5	1.8	11	2.2	23	1.8	5	1.5	6	3.2	21	2.5	16	3.0	13	1
801 meters	5.0	6	4.3	6	7.2	9	5.5	11	4.8	7	5.7	16	8.6	25	8.0	18	0
1,530 meters	4.4	5	4.7	3	4.0	15	5.1	7	4.7	10	6.1	20	8.7	32	7.7	18	0
3,060 meters	7.1	3	1.2	1	6.0	1	4.8	1	7.8	4	11.0	22	11.9	45	9.3	21	0
AUTUMN																	
Surface	2.3	4	1.8	9	2.2	20	1.5	2	1.4	2	4.4	29	2.6	18	3.0	14	2
801 meters	6.8	7	5.8	3	4.8	4	4.5	7	5.8	5	9.2	16	11.7	35	9.8	23	0
1,530 meters	7.1	6	2.4	2	6.0	2	4.4	3	4.9	7	8.2	13	11.4	41	11.7	26	0
3,060 meters	10.4	4	5.3	2	4.3	2	4.4	2	8.7	3	12.2	11	12.8	41	14.3	34	0
WINTER																	
Surface	2.2	4	1.8	8	2.2	17	0.5	1	1.1	1	5.4	37	2.6	17	2.6	15	1
801 meters	9.2	5	3.7	2	3.7	1	3.4	1	5.1	3	9.4	15	14.3	38	11.4	35	0
1,530 meters	9.0	5	1.8	1	0.8	1	2.4	1	5.9	2	9.8	9	13.7	36	12.6	46	0
3,060 meters	14.1	10	8.2	1	0.0	0	1.8	1	6.0	2	7.3	6	13.6	35	15.1	45	0
SPRING																	
Surface	3.5	6	2.4	10	2.8	23	2.1	4	1.6	4	4.4	26	3.2	13	3.4	14	1
801 meters	6.2	8	4.0	6	6.7	6	10.2	8	5.3	6	8.5	18	11.3	31	8.1	17	0
1,530 meters	7.1	7	5.2	4	5.9	3	5.0	4	6.4	5	7.8	16	11.0	40	10.2	21	0
3,060 meters	8.3	9	8.7	2	1.1	1	1.9	1	5.0	2	10.4	14	12.3	47	12.6	23	0